Man on the Moon

Arrival mirrored in gold visor

First man on the moon a civilian

For Neil Armstrong, a boyhood dream comes true

WHEN Neil Armstrong was a skinny, freckle-faced kid in Wapakoneta, Ohio, he took a job sweeping out a local pharmacy before and after school for 40 cents an hour.

What the 14-year-old did with his earnings shaped his life and started him on the journey that took him to the moon.

Another boy might have spent his money on sports equipment or taking girls to the movies—Neil Armstrong took flying lessons.

For two years, Armstrong would bicycle down "Old Brewery Road" to the hanger of the Wapak Flying Service, hand over his pay to instructor Charles Finkenbine, and race over to the light plane used for flying lessons.

On his 16th birthday, Aug. 5, 1946, he received his pilot's license.

Flying has been Armstrong's passion and his life.

The only civilian on the moon flight, he is also the best paid of the astronauts. As a senior NASA research pilot he receives over $27,000 a year, considerably more than his colleagues who are on military pay scales.

FREQUENTLY described as "an enigmatic "loner," Armstrong is an intense, self-contained man with love of the outdoors and a loathing of exercise.

As the first man to set foot on the moon, Armstrong's place in the history books is assured, but he already had an historic first to his credit before the moon flight.

As command pilot for the Gemini 8 mission, which was launched three years ago, he performed the first successful docking of two vehicles in space.

That flight was originally scheduled to last three days. But the joined spacecraft started to roll. Armstrong fought for control and finally found the trouble, a stuck rocket thruster.

Ground control ordered him to come home 10 hours into the mission. Gemini 8 made an emergency re-entry and landed in the Pacific.

Armstrong had faced earlier challenges.

THE blond, blue-eyed pilot flew 78 combat missions as a Naval aviator in Korea, beginning at age 19. Once, anti-aircraft fire crippled his jet, and he had to bail out.

By the time he was 25, Armstrong had served four years in the Navy and then earned a bachelor of science degree in aeronautical engineering from Purdue University.

He joined NASA's Lewis Research Center in 1955 after graduating from Purdue and later transferred to the then NASA High Speed Flight Station at Edwards Air Force Base, Calif., as an aeronautical research pilot.

His job was project pilot for the X15 Rocket Plane. He flew it to over 200,000 feet and at approximately 4000 miles an hour.

A SUPERB pilot, he has logged more than 4000 hours flying time.

The 39-year-old astronaut was one of the second group to be chosen and has been training since 1962. Trim at 165 pounds and five feet 11 inches tall, he looks younger than his years.

Armstrong is the son of Mr. and Mrs. Stephen Armstrong of Wapakoneta, Ohio. He is married to the former Janet Shearon of Pasadena, Calif., and they have two boys, Eric, 12, and Mark 6.

Edwin "Buzz" Aldrin—a moonwalking PhD.

"IF BUZZ were a trashman and collecting trash," says the wife of Air Force Col Edwin Aldrin, "he would be the best trash collector in the United States."

As the second man on the moon, Aldrin finds himself in what is for him an unusual position—he's usually first.

He's never collected trash but Aldrin gathers up facts like a computer and has been called the finest scientific mind to be sent into space.

A balding, self-driven perfectionist, he became the first astronaut to beat the fatigue problem of space walking by exercising self-discipline and learning to pace himself properly.

He became the world's champion spacewalker during the Gemini 12 mission in November, 1966.

Aldrin spent more than 5½ hours outside the spacecraft, including one stretch of two hours and 28 minutes. Until the Moon mission, this was the longest time a man had been exposed to the dangers of space.

Aldrin is perhaps the most technically qualified of all the astronauts, and the only one entitled to be called "doctor."

He earned his doctor of science degree at M.I.T. in 1963. Subject of his dissertation: orbital mechanics and rendezvousing in space.

AND, fittingly enough, the astronaut is the son of a former pupil of space pioneer Dr. Robert W. Goddard.

His father, retired Air Force Col Edwin E. Aldrin, formerly of Worcester, and now of Brielle, N.J., was graduated from Clark University in Worcester in 1915.

Goddard, who is considered the father of modern rocketry, was a physics professor there at the time.

Young Aldrin got the nickname "Buzz" while still a child. His sister couldn't pronounce "baby brother." It came out "Baby Buzzer."

The family shortened it to "Buzz."

Aldrin entered the United States Military Academy at West Point in 1947 and was graduated in 1951. He became an Air Force pilot the next year and flew 66 combat missions in Korea.

On leave before going overseas, he met Joan Archer of Ho-Ho-Kus, N.J. They now have three children, James, 13; Janice, 11; and Andrew, 11.

He wrote his doctoral dissertation at M.I.T. with a dedication to "the men in the astronaut program."

"O, that I were one of them," he wrote.

LATER that year he got his wish and was transferred to NASA's astronaut program.

He almost missed being allowed to fly in space. Several years ago he injured a knee while jumping on a trampoline and later reinjured the knee while playing squash.

However, an operation to remove torn cartilage repaired the damage.

Editorial material for this section prepared by Globe staff writers: Robbert Anglin, Herbert Kenny, William Davis and Victor McElheny.

Dream of the ages:

Reaching to the horizons in the vast expanse of space

"When I consider Thy heavens, the work of Thy fingers, the moon and the stars which Thou hast ordained: What is man that Thou art mindful of him?"

– Eighth Psalm, quoted by Astronaut Aldrin, July 23, 1969 during return flight to Earth.

JUST before 10:56 p.m. EDT on the evening of July 20, 1969 a picture flashed onto the screens of television sets in many corners of the earth.

A few hours earlier, the world had learned that two men, Neil Armstrong and Edwin Aldrin, had piloted a lunar landing craft called Eagle down to a landing not far from a "football-field sized crater" strewn with boulders.

But even though the men's voices came through, "loud and clear," across 240,000 miles of empty space, it was difficult to believe.

Now, suddenly, dot by dot, line by line, far faster than the eye could follow, there was a television picture from the surface of another world.

A ghostly white figure, his face shrouded by a thick sun visor, stood on a ladder.

It was Armstrong, ready to take his small step for a man that seemed a giant leap for mankind.

IT WAS possibly the most anticipated, predicted, forecast moment in the history of man. Millions of words had poured through the increasingly elaborate channels of communication which mankind is building for itself, attempting to tell people of the exact quality of the moment that lay ahead.

But when the moment came, it was clear that the words were inadequate. The moment was, all told, as total a surprise as any who saw it are likely to witness.

The moon was both more lonely and more familiar than anyone would have forecast. The scene was eerie and remote, and yet as familiar as a desert in the American West.

Nothing could equal the starkness of the lunar surface as the two astronauts stood at attention during President Nixon's telephone call, which noted that for one supreme moment, all men were truly one.

The voice of the head of state of the most powerful and wealthy nation ever to have existed could easily reach the two astronauts placed on the moon by the effort of that nation.

But if there had been a failure of equipment at Tranquillity Base, no power on earth could have rescued the astronauts.

Visible to all mankind, they were alone.

BUT even if mankind could send no rescuers, hundreds of thousands of people had done everything in their power to make the equipment which sent the astronauts to the moon, and supported their life there free of defects.

To do this, these people had had to reach new standards of excellence, new sophistication in planning and a new intensity of generous cooperation.

A symbol of that cooperation was the voice of Mission Control in Houston, asking questions of the astronauts and reminding them of what was next on their crowded lunar surface program.

It seemed fitting that the astronauts should be addressed by their first names, as if they were members of the immense family of man that was watching.

It was, as one onlooker remarked later, as if the American space program was sending more than laser beams to the moon. It was sending a little love.

The astronauts moved with ease about the lunar surface, evidently enjoying the sensation of walking on a body where the force of gravity is one sixth that of earth. They seemed almost to be waltzing, like characters in a dream. Fears for their survival receded if they did not altogether disappear.

No one could have known that a landing on the remote moon would be so immediate, so intimate.

AND while mankind concentrated its vision and emotion on the new horizon that was the surface of moon, it was so absorbed that few gave much thought to a more distant horizon which came into view little more than a week later – the first close-up television views of the planet Mars.

These pictures, while still fuzzy, were at least 10 times clearer than any taken by the first television camera to visit the vicinity of Mars, that of mariner IV in 1965. And while the cameras were on their way to Mars aboard American spacecraft called Mariners, they took pictures of the entire illuminated hemisphere of the planet.

These views taken over two days, provided Martian photos that are far clearer than those which are possible from telescopes on Earth.

Thus in the past few weeks, mankind has been taken to one new, still nearly unbelievable horizon – and then on into space to still another.

"... The most historic phone call ever made...."

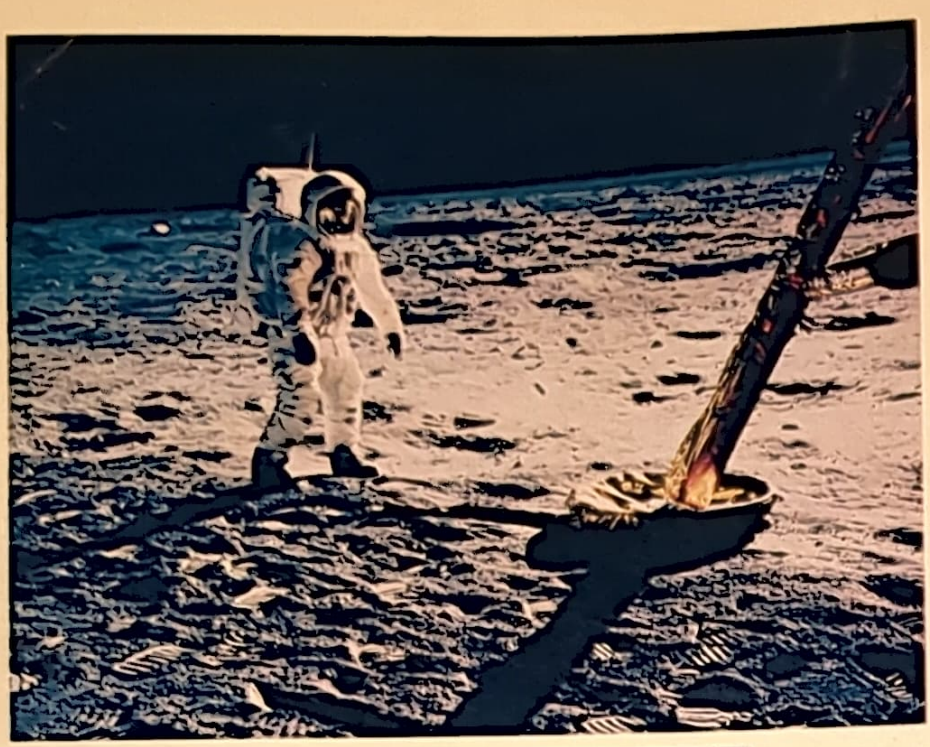
IT cost billions of dollars to put men on the moon but only 75 cents to call them up once they got there.

That was what President Nixon was charged for a regular, three minute toll call from the White House in Washington to Mission Control in Houston, which relayed the message by radio to Astronauts Armstrong and Aldrin.

"Of course, he dialed on Sunday so he got the weekend rate," a telephone company spokesman said.

No particular technical feat was required for the President to make the call, the spokesman said, he just dialed the Houston switchboard directly and they switched the call into their radio telephone equipment.

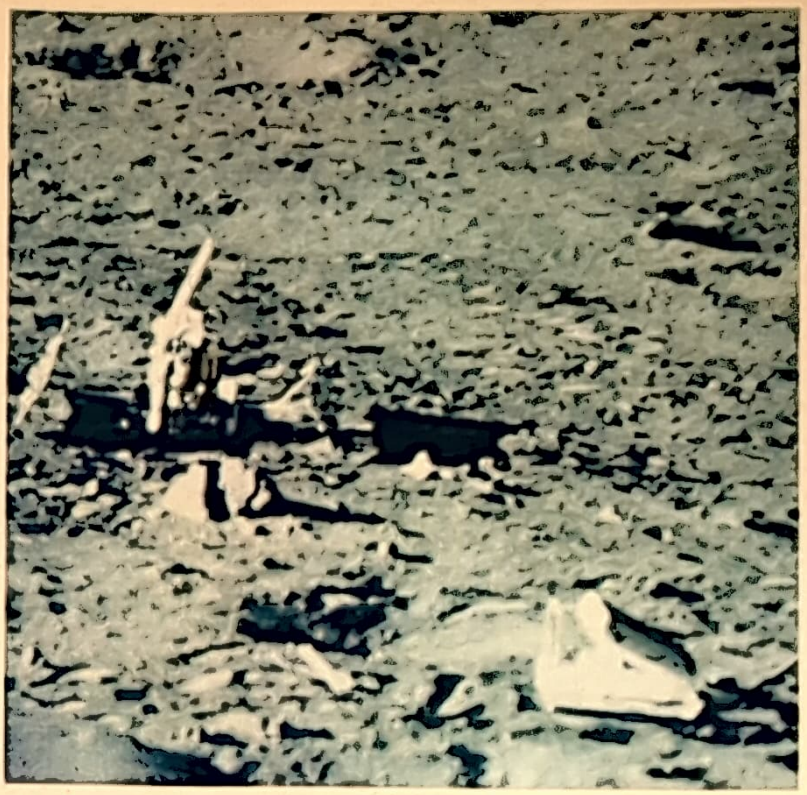
"The hard part was getting to the moon," said the spokesman, "all we had to do was get from Washington to Houston."



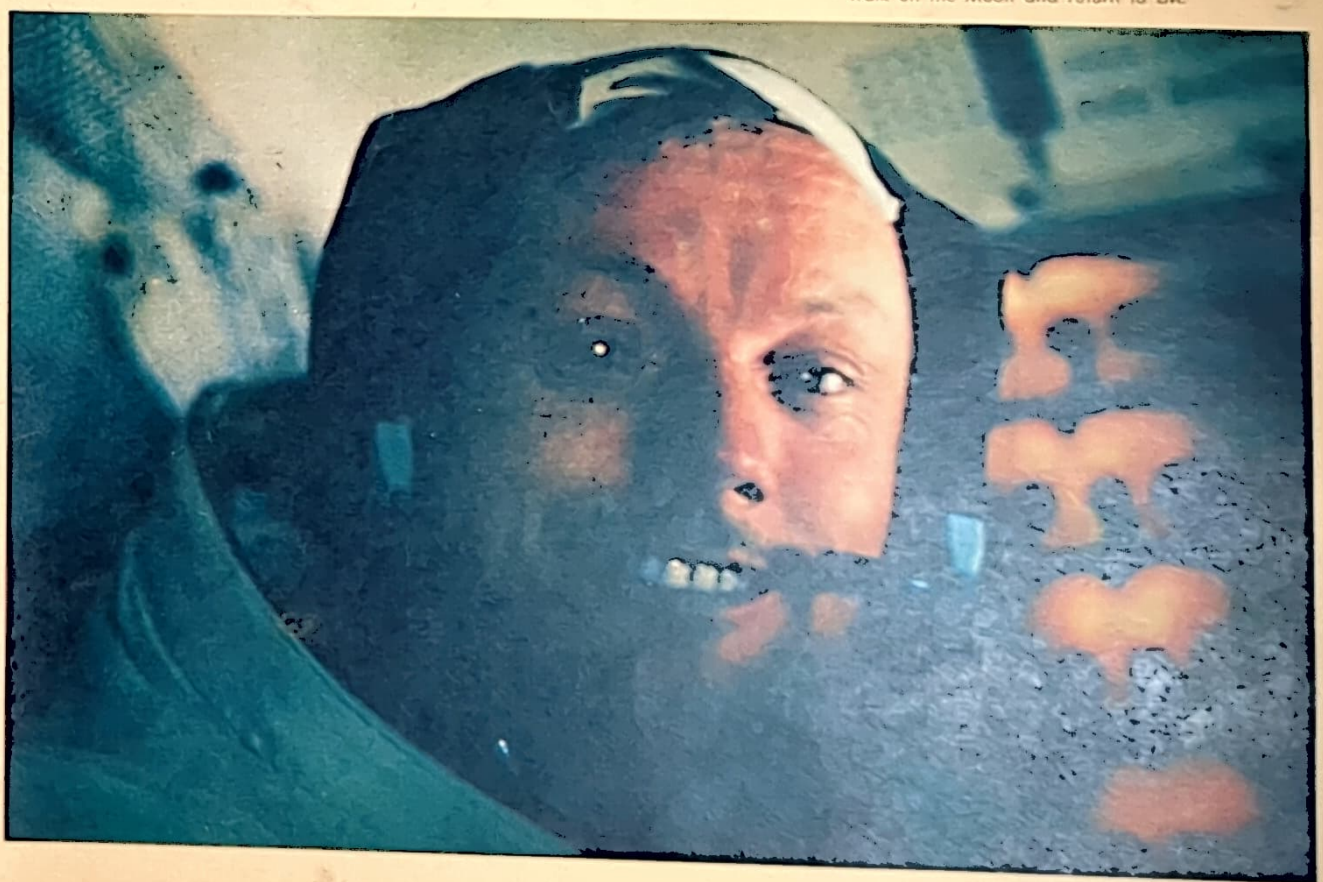
Aldrin walks near LM leg.

Astronaut Armstrong (left) displays flag with help from companion Aldrin. Above, Armstrong takes first slow step onto surface; recorded for history on 16 mm film.

With left foot, Aldrin readies his first step on moon.



Two experiments placed on Moon's surface: Seismic package and, to right, laser reflector.



Happy Neil Armstrong photographed by "Buzz" Aldrin just after they complete walk on the Moon and return to LM.

Michael Collins, the third astronaut:

Riding circles around the moon

THE lonely man of the moon flight, Air Force Lt. Col. Michael Collins, almost didn't make the trip—and ran great risk to insure that he would.

A cool, athletic, deceptively slender man, Collins is the handball champion of the astronauts. Last year his game started to fall off and reflexes to deteriorate.

The feeling was like "instant old age," he said. Doctors discovered that the cause was a bone spur and loose disc in his neck which pressed against his spine and advised surgery.

There are two major operations for this condition, one which relieves it and another—more complex and much more dangerous—which will cure it.

CHARACTERISTICALLY, Collins chose the latter. His recovery was complete and although he missed his chance to go on Apollo 8, first flight around the moon, he realized his goal of commanding the command module for the moon landing.

Of all the astronauts, he has the closest Boston connection, having married the former Patricia Finnegan of Dorchester, whom he met while he was stationed at Chambley AFB in France, where she was a recreation director.

As a boy Collins was nicknamed "scarecrow" because of his slender frame. Now, at five feet, ten inches, he weights 165 pounds.

He was born in Rome, Italy, on Oct. 31, 1930, where his father, the late, Maj. Gen. James L. Collins, was military attache at the United States Embassy.

His family has a tradition of military service. Gen. J. Lawton Collins of the Army is an uncle.

HE attended St. Albans, a prep school in Washington, D.C., and then went to the military academy at West Point, from which he was graduated in 1952.

He served as an experimental test pilot at Edwards AFB in California, primarily flying jets, and has logged more than 4,000 hours flying time.

Collins had to apply twice before he was accepted for astronaut training. He was passed over in 1962, but was selected in 1963 as one of the third group of astronauts.

Three years ago, Collins shared with astronaut John Young the record setting Gemini 10 mission.

Astronaut Collins poses with his family: his wife, Patricia of Dorchester, Mass. and children Kathleen, 10; Ann, 7; and Michael, 6.

Lonely Mike

In all the history of mankind, nobody has been quite so lonely as was Mike Collins on July 20.

While fellow astronauts Neil Armstrong and Buzz Aldrin were taking their historic walk on the lunar surface, Collins made 14 solitary orbits of the moon in the space ship "Columbia."

An estimated 500,000,000 people on earth saw the moon walker on television but since there was no television receiver on "Columbia," Collins was one of the few citizens of an advanced nation with no opportunity to watch the historic event.

Rescue: the Impossible Mission

IF they had run into difficulties on the surface of the moon, could Neil Armstrong and Edwin Aldrin have been rescued? No.

Their only way of returning to Earth was to use the uncomplicated and powerful ascent propulsion rocket of their lunar module to get back up into lunar orbit. There, they could have begun maneuvering to rejoin their colleague, Michael Collins, or waited for Collins to rescue them. Collin's command module was not equipped to land.

A rescue flight from Earth was out of the question. The next mission capable of landing on the moon is Apollo 12, which is proceeding on a schedule to allow it to take off from Cape Kennedy in September at the earliest.

EVEN if the Apollo 12 crew of Charles Conrad, Richard Gordon and Alan Bean had completed their training and their rocket was completely ready, they could not have reached the lunar landing site before the Apollo 11 Lunar Module's batteries were dead and its oxygen supply exhausted.

The minimum time between a takeoff from the Earth and a landing on the moon cannot be shortened much below 96 hours even for a rescue. The oxygen supply on the LM allows 49 hours from the time astronauts enter it to start down to the surface and when they leave it after a successful rendezvous with the "mother ship."

Even the normal Apollo 11 schedule called for more than 28 hours of continuous oxygen use. An emergency might well happen when the astronauts had used much of their supply.

The most catastrophic problem that could have occurred to astronauts on the moon would have been the total failure of communications. This probably would have prevented an ascent from the lunar surface and would have meant that the astronauts could not have discussed the emergency with Collins above or Mission Control in Houston—nor passed on any lessons.

Moon rocks, quakes

Raising more questions

First lunar sample photographed at receiving laboratory in Houston. It's a granular, fine grained, iron-magnesium-rich rock.

THE earliest scientific results from the Apollo 11 mission to the moon confirmed advance suspicions that the first hunks of lunar rock to be examined in a laboratory on Earth and the first signals from a group of seismographs on the lunar surface would raise more questions than they settled.

The age of direct scientific exploration of the moon began soon after Neil Armstrong's first step onto its surface, when he collected a two-pound "contingency sample" in a plastic bag. Soon afterwards, Armstrong and Aldrin set up an array of quartz crystals for reflecting laser beams back to their sources on Earth (the array was assembled in Cambridge) and the seismographs (one of the scientists working on this experiment is Prof. Frank Press of the Massachusetts Institute of Technology).

The seismographs began working while the two astronauts still walked the moon early July 21. In the first week, the automatic seismic station recorded three apparent moonquakes and tremors from landslides in nearby lunar craters.

The traces from the moonquakes were identified by scientists as shocks which had traveled along the moon's surface, probably for hundreds or even thousands of miles. The occurrence of three such shocks in a few days' time cast doubt on the theory that they had been caused by large meteoroids crashing into the moon.

The scientists felt they could easily distinguish the coherent "wave trains" from the apparent moonquakes from the jumble of noise caused by the settling of the seismographs into dusty soil, and the movement of gases in the propellant and pressurant tanks and batteries of the Descent stage of the Lunar Module, left behind on the surface, as well as flexing in the joints of the LM's legs.

THE so-called landslides apparently were coming from two craters not far from the LM that are nicknamed West and South Craters. In them, the double effect of solar heating during a two-week day and deep cold during a two-week night would fragment many rocks, scientists think. The landslides would occur at a time of maximum heat-change near lunar noon, according to Dr. Gary Latham of Columbia University, chief scientist of the seismograph project.

The first rocks to be examined in high vacuum chambers at the Lunar Receiving Laboratory came from the second box the astronauts used during their moonwalk. This box weighed 33.35 pounds when it arrived in Houston, including about 15 pounds of moon. The other box, weighing 52 pounds, contains an estimated 38 pounds of lunar material.

After a disappointing first look in which a large bag full of rocks was seen to be covered with fine gray dust, the scientists soon began finding large numbers of tiny glass droplets – presumably formed during meteorite impacts – a few tenths of a millimeter in diameter. The scientists also found an unusually high percentage of titanium oxide in the rock samples.

Moon's first man-walker reports:

"It has a stark beauty all its own"

NO ONE was surprised that the first man to set foot on the moon should find it bleak and desolate but few people expected that they would call it "pretty."

"It has a stark beauty all its own," Neil Armstrong said, "It's like a high desert of the United States, a little different, but it's very pretty out here."

For Buzz Aldrin, the second man on the moon, the lunar surface was "a magnificent sight."

The view was a lot better than expected, but otherwise the moon turned out to be pretty much what scientists had predicted it would be.

The two astronauts were the first men to confront an alien environment in which they weighed only one-sixth as much as on earth, where a "day" lasts two weeks and the airless sky is black at noon, and where the curvature of the planet is so steep that the horizon is only a couple of miles away.

Armstrong and Aldrin were trained for the unexpected – but most of the surprises were happy ones.

One fear expressed by some scientists was that the moon's surface was covered with a deep layer of powder which would envelop the module and the astronauts.

THE surface proved to be "fine and powdery" as predicted but not very deep and the lunar module foot pads sank in only about three inches. Aldrin had some difficulty driving a "core" tube into the surface about five inches to take samples.

"I hope you're watching now how hard I have to hit this into the ground to the tune of about five inches," he told viewers.

As he walked across the moon surface, Armstrong said, the soft surface clung to his boots "like charcoal."

The astronauts unveiled a plaque and left behind an American flag but the most enduring memorial may well be their footprints.

There is virtually no erosion by wind or water on the moon and astronomer Fred L. Whipple of the Smithsonian Astrophysical Observatory in Cambridge estimates that the footprints could last a million years.

The problem of moving around in a 6G environment had been anticipated and apparently overestimated. The astronauts had been carefully trained to do "the kangaroo hop," a step expected to enable them to keep their balance in the low gravity environment.

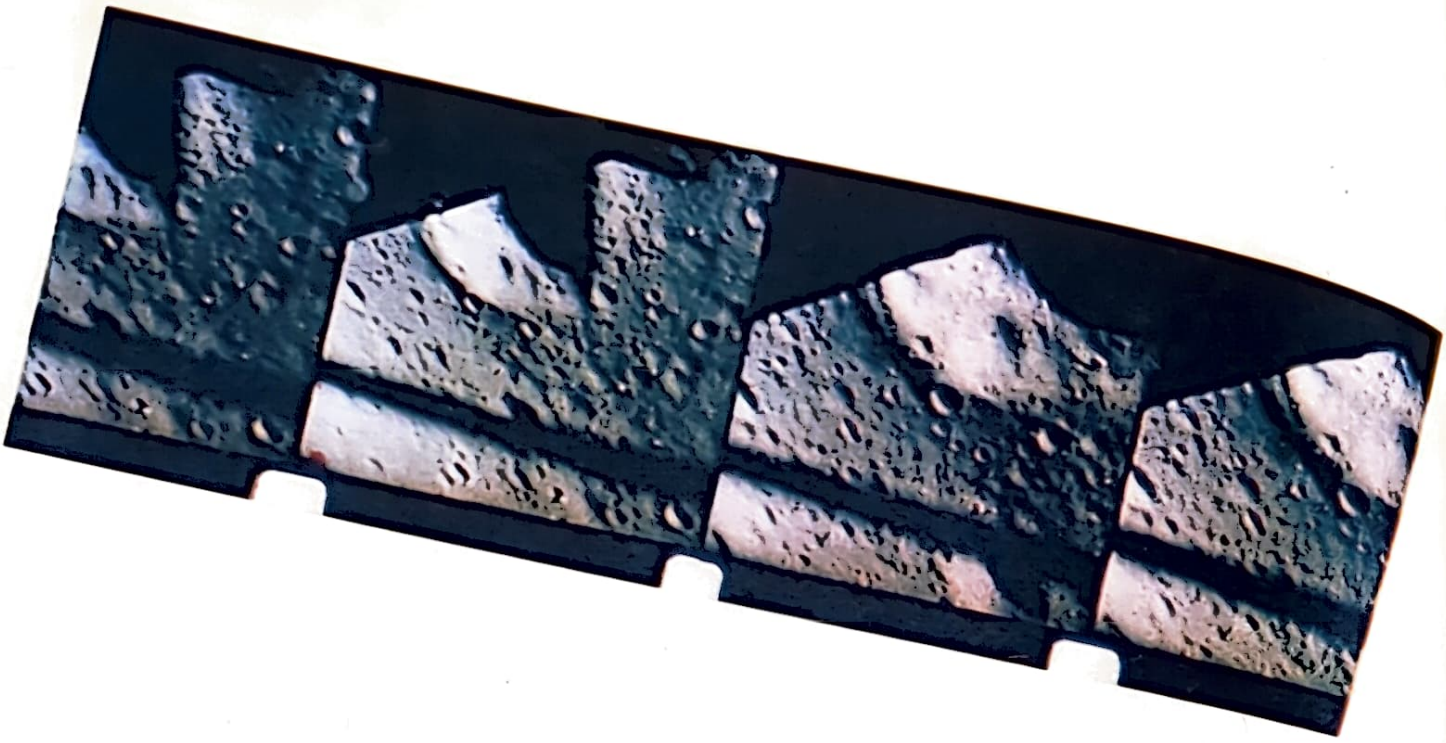
They found that a normal walk worked just as well, if not better.

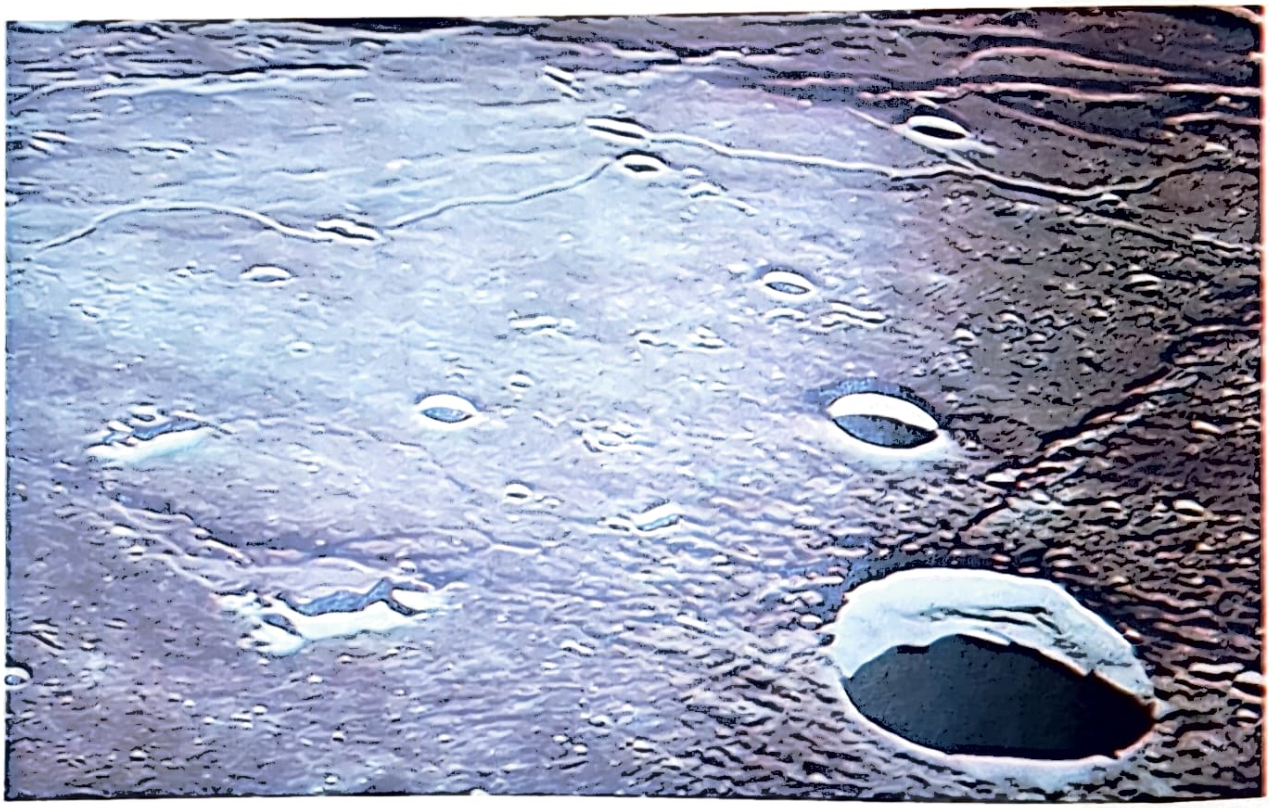
"So-called kangaroo hop does work but it seems that your forward ability is not quite as good as it is in the conventional one foot after another," Aldrin said.

CREDIT for so much of what was known about the moon before the historic Apollo 11 flight must go to the unmanned Surveyor craft which began landing on the moon in June, 1966. The Surveyors radioed back thousands of pictures showing fields of rocks and a surface that looked like sand.

The key to the astronauts' survival on the moon was their lunar suits and portable life support units, which had an attached emergency oxygen supply. The life support units were made by Hamilton-Standard of Windsor Locks, Ct.

As the astronauts worked, the suits handled the heat loads by constantly circulating cool water through thin plastic tubing running back and forth inside the liquid-cooled underwear they wore next to their skin. The system also circulated cool, pure oxygen at a pressure of 3.85 pounds per square inch, removed moisture and carbon dioxide which the astronauts breathed out and stored urine in a 900 cc container.





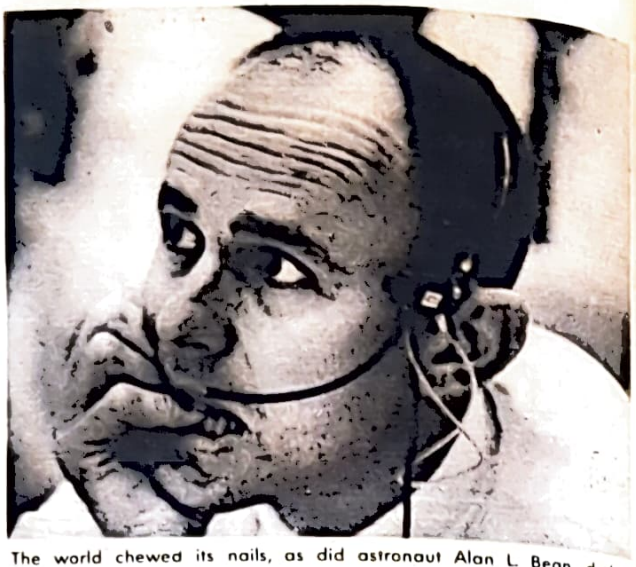
Approaches to landing site taken from 69 miles above the moon, before Columbia and Eagle, still in orbit, have undocked. Crater Maskelyne is at lower right. Sidewinder Rille and Diamondback Rille extend from left to right across the picture.

Four frames of 16 mm film, taken automatically by camera under LM, show (from far left): approach from several hundred feet, boulder-filled West Crater avoided by Armstrong, closer view of crater hazard and rays of dust caused by engine of LM.

Closeup of astronauts' footprints, expected to last thousands, if not millions of years.

July 16-July 24, 1969

When the world held its breath



The world chewed its nails, as did astronaut Alan L. Bean, during Moon flight.

Wednesday, July 16, 1969

9:32 a.m. They're off!

The Saturn V rocket, weighing 6,484,000 pounds, most of it fuel, stands on its pad at Cape Kennedy . . . at 6:45 a.m., astronauts go aboard the spacecraft perched atop the rocket . . . countdown continues, even gets 15 minutes ahead of schedule, despite leaky valve in fuel system . . . then from Paul Donnelly, in Firing Room 1: "Good Luck and Godspeed from the Launch crew" . . . and from a casual Neil Armstrong: "Thank you, we know it will be a successful flight" . . . saffron flames spew from the Saturn . . . burning for an almost endless 8.9 seconds . . . "We have liftoff" from the firing room . . . followed moments later by a terse "we've got a roll program" from Armstrong.

Thursday-Friday, July 17-18, 1969

Orbiting earth for 2½ hours, checking, double-checking . . . third stage fires, hurtling Apollo 11 into lunar trajectory, 24,200 m.p.h. . . . in next two hours command module separates from 3rd stage, links up with Lunar Module and pulls away from rocket stage . . . now more than 50,000 miles from Earth.

Saturday, July 19, 1969

Apollo 11 coasts on . . . live TV brings viewers into command capsule and lunar module . . . spaceship passes midpoint of trajectory at a slow 3600 m.p.h. then picks up speed under influence of lunar gravity.

12:16 p.m. Lunar trajectory

Lunar orbit achieved – "It went like perfect" radioed Armstrong after 1:22 p.m. engine burn as capsule went behind Moon . . . preparations continue for undocking and Moon landing Sunday. . .

Sunday, July 20, 1969

It's "go" for undocking . . . awake at 7 a.m., breakfast, Armstrong and Aldrin crawl through tunnel into lunar module . . . 12 of the 15 latches holding craft together are released . . . still docked, spacecraft goes behind the Moon . . . when communications re-established, Armstrong reports "Eagle has wings . . . 2:12 p.m., Columbia fires rockets, moves away from Eagle . . . both move behind Moon, where descent firing begins . . . 3:08 p.m., LM fires descent rocket . . . 3:46 p.m., Collins chortles: "Listen Baby, things are going just swimmingly, just beautiful" . . .

1:50 p.m. "Eagle has wings"

3:46 p.m. "Just beautiful"

Powered descent begins, 13 minutes to a soft landing . . . "Better than the simulator" says Aldrin . . . in seven minutes, Eagle at 7200 feet, landing site 5 miles ahead, craft tilts towards the vertical, giving Armstrong and Aldrin first view of Moon landscape . . . "You're go for landing" . . . at 300 feet Armstrong takes manual control, avoids crater strewn with boulders, fuel supply down to 49 seconds . . . Blue "Lunar contact" light flashes on. Armstrong (his pulse rate shoots up to 156 a minute) . . . "We copy you are down, Eagle" from Mission Control . . .

4:17:40 p.m. "Eagle has landed"

"Houston, Tranquility Base, here. The Eagle has landed." . . . "Roger Tranquility, we copy you on ground. You got a bunch of guys about to turn blue. We are breathing again. Thanks a lot."

(Eagle, however, had been close to aborting. Its computer repeatedly warned that it had too much work to do, might have to recycle. Determined men at Mission Control relieved computer of some chores, advised Armstrong to continue. Top NASA officials later said it had been a very close thing.)

10:56:20 p.m. On the Moon

Six hours later, Armstrong made history – the first man to step on the Moon . . . "I'm on the porch" . . . "I'm at the foot of the ladder" . . . "That's one small step for a man . . . One giant leap for mankind" . . . at 11:16 p.m. Aldrin clambered down the ladder, the second human ever to walk on another planet . . . placement of experiments, photography, practice walking, gathering of samples . . . then by 1:10 a.m. both astronauts back in cabin . . . cruising overhead in Columbia, Collins says: "Hallelujah"

Monday, July 21, 1969

After a "poor" sleep, preparations for ascent, on which safety of astronauts depends . . . "You're cleared for takeoff" . . . "Understand, we're No. 1 on runway" . . . "First stage engine on ascent . . . beautiful . . . very smooth . . . Right down U.S. 1" . . . "Eagle is back in orbit . . . we're all yours, Columbia. . ."

1:37 p.m. "Go"

"All hell's breaking loose" said Collins later of the wobbling that accompanied docking . . . but the crew of Apollo 11 is reunited . . . how does Collins feel about it? "Damn Good" . . .

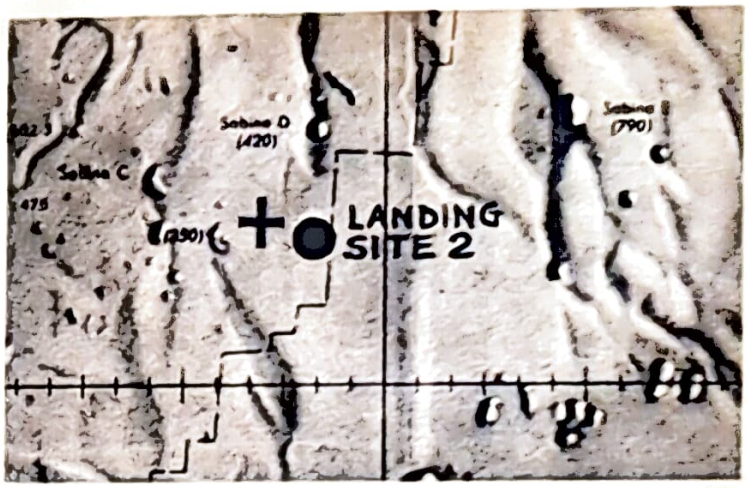
5:36 p.m. Rendezvous

Thursday, July 24, 1969

Coasting back to Earth from the timeless Moon . . . telecasts for "the kids" and of the astronauts' feelings about the historic voyage . . . ready for splashdown Thursday on the ever-changing Earth . . . Re-entry normal, spaceship hurtles towards Earth . . . splashdown only slightly off planned target, in Pacific Ocean . . . recovery normal, astronauts go by helicopter taxi to carrier Hornet, greeted by President Nixon.

12:50 p.m. Splashdown

Tranquility Base (its approximate location marked by +) was west and south of area pinpointed on Museum of Science map as Landing Site 2. Armstrong flew "Eagle" manually to avoid a crater the size of a football field, filled with boulders.



Avoiding contamination

Isolation—the price of glory

FEW students of the moon take seriously the idea that astronauts could contaminate the moon or that something on the moon could contaminate the earth.

Most of those who study the moon are astronomers and others trained in the physical sciences. They are certain that the moon offers an extremely unfavorable environment for anything living which could be brought there from Earth—or be brought back to Earth to spread some deadly disease to which mankind would have little or no resistance.

The moon has no free water on its surface and no detectable atmosphere. The range of temperature between the dead of night and the heat of high noon is 500 degrees fahrenheit, from 250 below to 250 above.

MANY scientists think that the moon has lacked both water and air for billions of years and that during all that time its surface has been bombarded steadily by deadly radiation showers from the sun. Any organism that could get along without air and water, stand the heat cycle and the radiation for billions of years would have to be pretty hardy.

And besides, according to Dr. Philip Abelson, the editor of Science magazine, any such organisms have already had their crack at Earth—by being carried here aboard fragments from meteorite impacts on the moon. He says, "It has been estimated that millions of tons of unsterilized lunar material have reached the earth as a consequence of meteor impact."

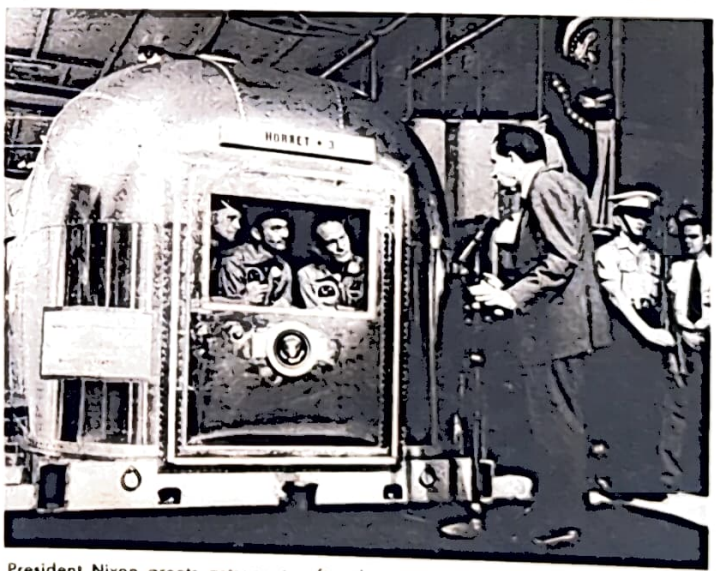
Nonetheless, the astronauts took heavy precautions against returning to Earth with any deadly moon-bug. They either left things behind on the lunar surface in bags or in lunar orbit, and then they vacuumed most of the things they brought back to Earth.

As Neil Armstrong and Edwin Aldrin entered their Command Module "mother ship" to rejoin Michael Collins, a device maintained a positive air pressure against any harmful particles that might float in from the Lunar Module.

On the three-day homeward journey, the air the astronauts breathed was circulated constantly through regularly replaced lithium hydroxide cannisters.

WHEN they splashed down in the Pacific, Armstrong, Collins and Aldrin were given biological isolation garments to don before entering life rafts to get ready for the short helicopter hop to the recovery carrier. On the carrier, they entered a special isolation van in which they rode to Houston's Lunar Receiving Laboratory.

In this multi-million-dollar quarantine facility, which astronauts from subsequent lunar flights will use also, the astronauts are scheduled to remain at least 21 days from the time Aldrin and Armstrong left the surface of the moon. Three weeks is the incubation time for most human epidemic diseases.



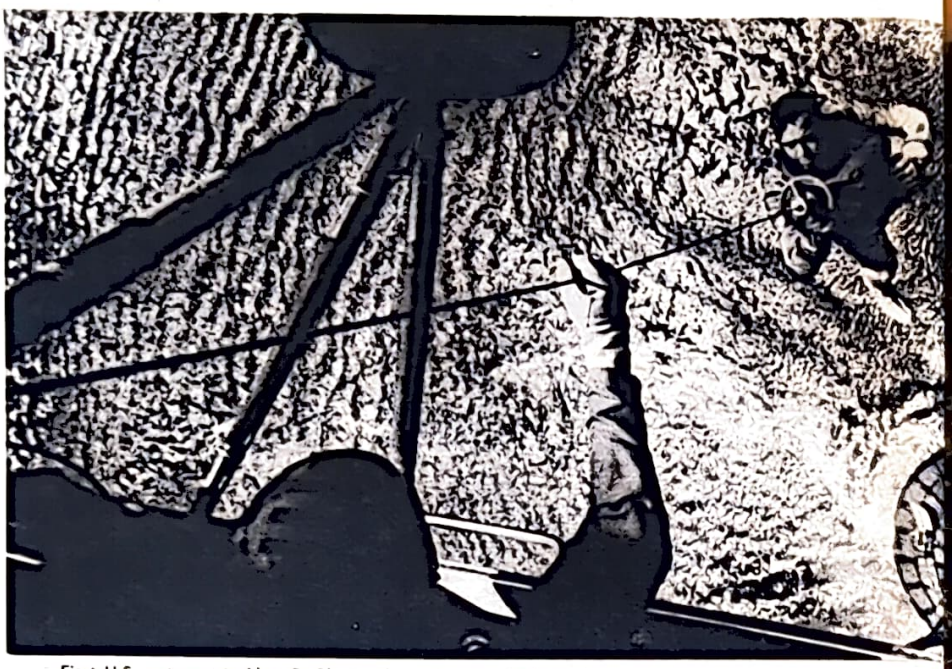
President Nixon greets astronauts after they enter isolation van. From left, Neil Armstrong, Michael Collins, Edwin E. Aldrin Jr.

Leaving helicopter on way to quarantine.

The American Flag
and man's footprints
from the
first lunar walk,
July 20, 1969.

Space goals set in 1961:

Be first, biggest, go the farthest



First U.S. astronaut, Alan B. Shepard Jr. of Derry, N.H., being pulled from the Atlantic Ocean after first sub-orbital flight May 5, 1961.

THROUGHOUT its eight-year history, the U.S. effort to land men on the Moon before the end of 1969 has been under fire.

Many scientists have argued that if the aim of the Apollo program is to stimulate American science and technology, the money should be spread more evenly among many fields and that the government should look hard at whether the astronauts on the moon can tell us more than instruments could.

Many others, including the beleaguered mayors of American cities, have said again and again that spending $2 to $3 billion a year on the moon trip was robbing money from badly needed social programs.

The replies have been many and some of them contradict each other.

It was said, for example, that civilian adventures in space would be an admirable training ground for later military exploits. At the same time, it was argued that heavy spending on competition in space would slow down U.S.-Soviet competition on arms.

IT was argued that many of the most valuable scientific findings in space would not have been made if the information hadn't been needed for the manned space flight program: Rangers and Surveyors and Orbiters would not have revolutionized our knowledge of the Moon.

Furthermore, proponents of the space program said that it provided employment for hundreds of thousands of people, helped to further stimulate the economic growth of California, Texas, Florida and other states, and forced the development of technology – particularly computer technology – that would provide new national wealth.

But perhaps the most important argument was prestige, a need to recover from a long string of Soviet "firsts" in space. The idea was that America's reputation in the world depended a good deal on people's opinion of our space program. For that opinion to be good, it was said, American rockets must do simple, spectacular things that people can understand.

That meant being first, biggest, farthest. In 1961, when the U.S. committed itself to the lunar landing, America's space program had been none of those things. Russia's had been all of them.

It took time for President John F. Kennedy to reach the decision for commitment, even though he had made a 1960 campaign issue out of America's second-place performance in space.

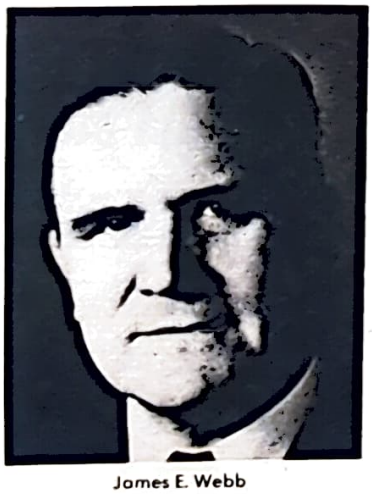
WHEN Kennedy took office, the civilian space agency, NASA, was barely two years old. It had just finished collecting activities, such as the Navy's Vanguard project or the Army's Redstone arsenal in Alabama, and adding them to the centers of its predecessor agency, the National Advisory Committee on Aeronautics (NACA).

NASA's plans had gone no further than a mission into orbit around the moon. Twice in 1960, NASA officials had told Congress that a lunar landing was a matter for the 1970's.

At the start of President Kennedy's administration, many in NASA feared that his science adviser, Dr. Jerome B. Wiesner, and others, wanted to shift many of NASA's activities back to the military. A report Wiesner issued just before the inauguration sounded that way.

Such fears reckoned without the ebullient personality, administrative experience and political connections of the new administrator of NASA, James E. Webb. It was Webb who got the moon program started and saw to it that it sank roots in

Dr. Thomas Paine



James E. Webb

Dr. Jerome B. Wiesner

"Now it is time to take longer strides... time for a great, new American enterprise."

—John Fitzgerald Kennedy, President of the United States, speaking to a joint session of Congress, May 25, 1961.

many parts of the country. He ran NASA until Oct. 7, 1968, when he turned the agency over to his hand-picked successor, the flat-voiced, calm Dr. Thomas O. Paine.

Webb was a man who talked with all the persuasiveness of a fire hose, a little overwhelming but hard to turn off. He started adult life as an assistant to a powerful senator from his native North Carolina.

He served as director of the Bureau of the Budget in Harry Truman's administration, and then was Dean Acheson's Under Secretary of State.

Webb became intimately involved in the vast business affairs of the late Sen. Robert S. Kerr (D-Okla.), and through Kerr, came to know Lyndon B. Johnson, then Vice President, very well.

BOTH Kerr and Johnson were dedicated to the economic development of the southwest, and at that time, Johnson's only substantive role was as chairman of the revived National Space Council.

Webb would have no interest in any dismantling of NASA, and he showed later on that he would brook no interference from Wiesner when Wiesner objected to NASA's choice of the method to go to the moon.

But even Webb could not hurry events in the Spring of 1961. To be sure, in March NASA got a 10 percent boost of $126 million above President Dwight Eisenhower's final budget request but it was $182 million less than NASA asked. Then, on April 12, the late Yuri Gagarin became the first man to orbit the earth.

Even the next day, however, President Kennedy said there could be other goals more worthy than a flight to the moon. He mentioned the development of an economic method to de-salt sea water.

Then, on Apr. 17 came the catastrophe of the Bay of Pigs, and on Apr. 21, Kennedy was peppered with hostile questions about the space race. In answer to one of them, he said, "If we can get to the moon before the Russians, then we should."

Mr. Kennedy announced that a study had been started to see "whether there is any effort we could make in time or money which could put us first in any new area."

A PUBLIC mood – if only temporary – was crystallizing in favor of a dramatic U.S. move in space. It was hardened further by the success of Alan Shepard's 15 minute flight into space May 5.

On May 25, President Kennedy spoke to a joint session of Congress and asked them for $600 million more immediately as a first installment on what became the $24 billion moon program.

But President Kennedy warned against faltering, against second thoughts: "If we are to go only half way, or reduce our sights in the face of difficulty . . . it would be better not to go at all."

THERE was faltering. There were second thoughts, particularly in 1963, but the commitment survived them. And so, on May 26 of this year, after Apollo 10 had successfully taken the last step before a landing, Dr. Paine could remark:

"While the moon has been the focus of our efforts, the true goal is far more than being first to land men on the moon as though it were a celestial Mount Everest . . . The real goal is to develop and demonstrate the capability for interplanetary travel."

The moon—a silent, barren place

MAN'S nearest neighbor in space, the moon is not a hospitable place.

Silent and barren, it probably has not changed much in billions of years.

There is no air for anyone to breathe, no water to drink, no food to eat.

On the average, the moon is 238,560 miles from earth, which, when measured against the far away stars or even the other planets in our solar system, is only a short step into space.

The moon is about one fourth as big as the earth. It has a diameter of approximately 2160 miles. If it were possible to set the moon down on the western part of the United States it would extend almost from San Francisco to Cleveland.

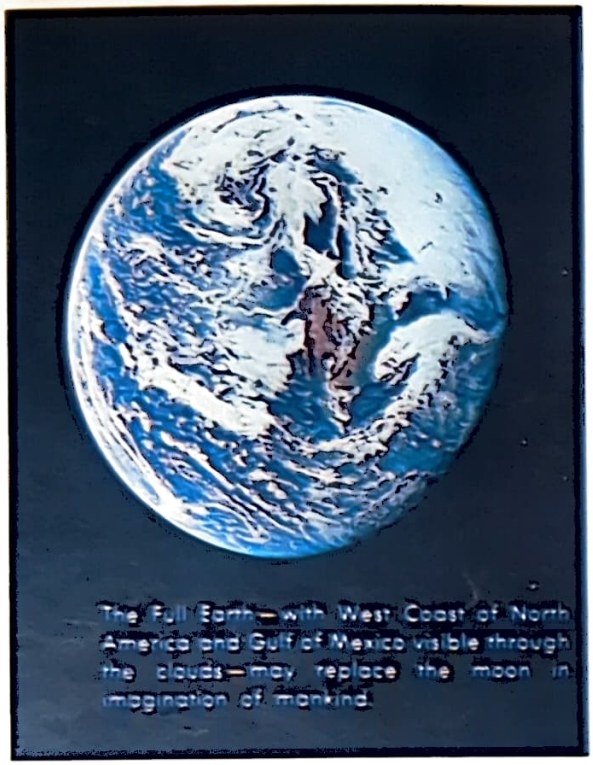
Daytime temperature is 250 degrees, hot enough to boil water. At night the temperature drops to 250 degrees below zero. These dramatic changes in temperature occur because the moon has no atmosphere.

THE moon weighs about 70 quintillion tons, about 82 times less than the earth, and its surface gravity is only a sixth of the earth's.

When the moon appears silvery, or, at times, orange, it is because the atmosphere of the earth has blocked off the darker light rays reflected from the sun.

The moon gives off no light of its own. When it shines it is really only reflecting sunlight. We see only a thin, bright crescent when the moon is almost between the earth and the sun. The rest appears dimly lighted.

This dim glow is earthshine, or sunlight that has been reflected from the earth to the moon and back again.



The Full Earth—with West Coast of North America and Gulf of Mexico visible through the clouds—may replace the moon in imagination of mankind.

From moon lore . . .

MANKIND has cursed the moon or sung its praises since time immemorial.

His imagination has been stirred through mythology, folklore or fact, and thus moonlore has become part of many cultures.

Among Westerners, the moon's features suggest a human face or figure. But the Chinese see a monkey pounding rice; Indians see a rabbit, and Samoans imagine a woman placidly weaving.

To ward off the supposed weird influence of the moon there were many ceremonies in olden times. One of them persists in the old wives' admonition that a person should count his money quickly after inadvertently seeing the new moon over his left shoulder.

Then there is romantic moon lore, such as the notion that a maiden who drinks white wine and rose water and then looks at the moon through a silken scarf will see the face of her future husband.

THE best of all lucky charms is the left hind foot of a rabbit killed in a graveyard by a cross-eyed person in the dark of the moon.

Everybody knows that the word "lunatic" is derived from the latin word "luna," meaning moon, and was originally applied to those believed to have fallen under the moon's influence.

Similarly, authors for thousands of years ascribed peculiarities of character to the fact that a person was moon struck, behaving like a moon calf or mooning about.

That pale, silvery light and the regularity of its cycles prompted early man to attach great significance to the moon.

It held a prominent place in the religion and mythology of ancient Rome and Greece. The moon was depicted as a goddess. The Greeks cast it variously as Artemis, the sister of Apollo; Selene, the sister of the sun god, Helios, or as Hecate, goddess of ghosts and witchcraft.

The Romans associated the moon with their virgin goddess of the hunt, Diana.

Man came to make use of the moon's regular rounds. Moon, menses and month, all have the same root, meaning to measure. Both the Mohammedan and Hebrew calendars are based on the lunar month.

. . . Man's vision turned to a landing!

THE first men landed on the moon just about 1800 years after the first science fiction writer plotted a trip that took men there.

He was Lucian (125 A.D.—190 A.D.), a Greek satirist, born in what is now Samsat, Turkey, a considerable literateur apart from his "True History," in which the first famous trip to the moon took place.

Lucian related that a ship was caught up in a huge waterspout near Gibraltar, which took it so high that when the spout subsided, winds caught the sails and swept the ship along to the moon. His adventurers found the moon populated.

The first account in English of a moon flight was given the world by Bishop Francis Godwin (1562-1637) who wrote "The Man in the Moon," which bore the subtitle, "Or, a Discourse of a Voyage Thither by Domingo Gonzales, the Speedy Messenger." The combination of names is enought to set an antiquarian wondering if the good bishop's story gave rise at length to a series of ribald yarns featuring "Speedy Gonzales."

In any event, the Gonzales in "The Man in the Moone," got himself there by hitching up a flock of geese and having them tow him. He too found the moon inhabited.

The most celebrated of such moon trips comes in a book written by Cyrano de Bergerac, a 17th century French wit, soldier and scientist of sorts, who was the model for the hero of the famous play by Edmond Rostand written centuries later. De Bergerac wrote, "A Voyage to the Moon," which was again translated into English in 1962.

IN this fantasy, de Bergerac sets out to get to the moon (Lucian's mariners and Godwin's hero arrived by accident), and devises two methods. The first fails. It was this: he argued that if the sun draws the dew into the heavens, a man has only to fasten to himself a number of bottles filled with dew and away he'll go. The attempt gets him from France to Quebec where he crashes.

In Quebec he fashions a machine which he hopes will take him to the moon. It does but only because the authorities fasten explosives to it to destroy it, which gave it additional power. What de Bergerac has forecast in his tale are rockets working in stages, and the balloon, raised by hot air, and the parachute. When he arrives on the moon, de Bergerac finds that it contains the Garden of Eden from which Adam and Eve were banished to this world.

The scientific knowledge of Lucian, Godwin and de Bergerac was minuscule. Jules Verne, who was one of the world's great story tellers, was not a professional scientist, but he was a professional science fiction writer, who came to glory in the last half of the 19th century. Among his many novels was "From the Earth to the Moon," which was extraordinary in the coincidental details running parallel to the actualities of moon flights today.

VERNE had his heroes shot from a gigantic cannon. They were Americans using technical knowledge developed during the Civil War. They fired their cannon from Florida, from a fictitious spot called Stone Hill, which Verne located on a legitimate map of Florida which identifies very few places, but uncannily, Cape Kennedy among them.

The shell fired by the cannon was not too dissimilar in appearance from our capsules, and having circled the moon (and observed things we now know aren't there) returned to earth to land in the sea. The artist's conception of the recovery of the capsule at sea has an incredible similarity to operations today. Verne also introduced the retro-rocket.

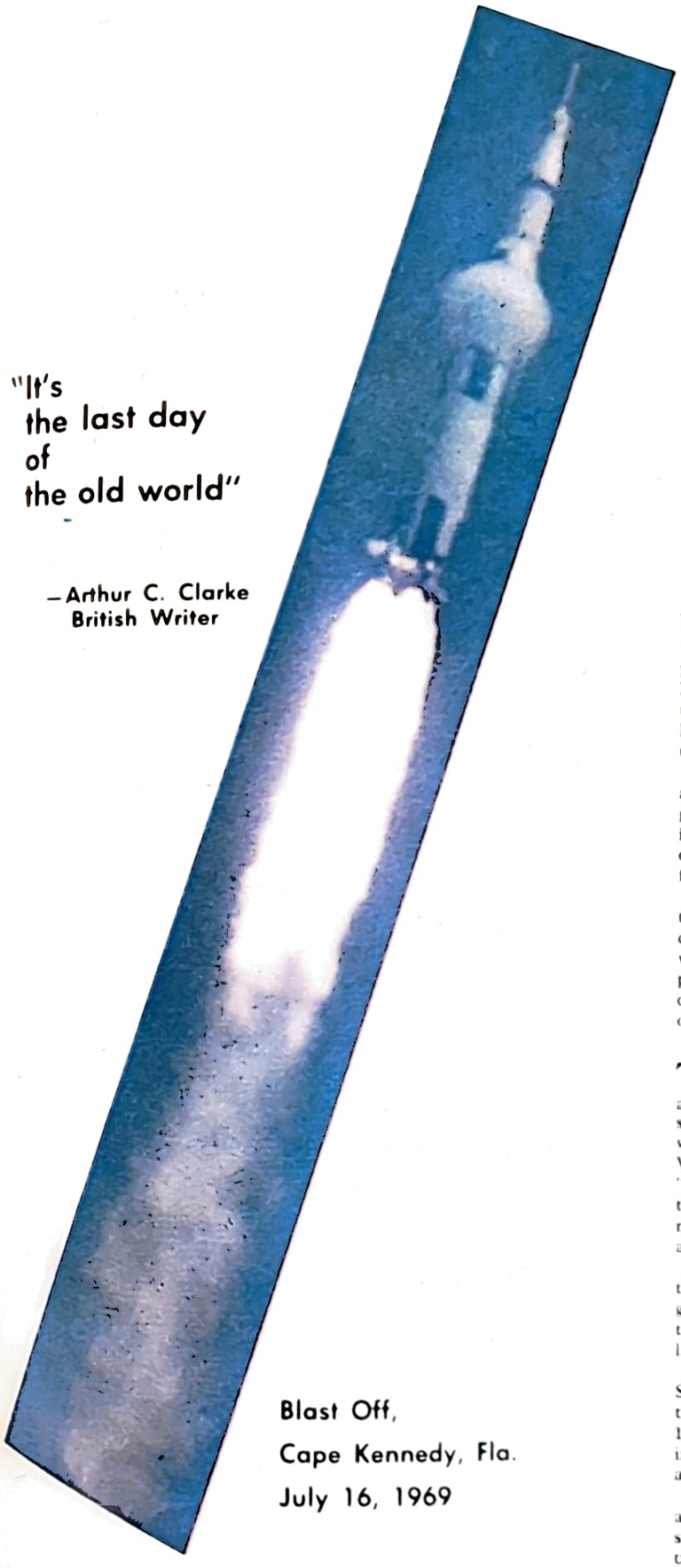
EDGAR Rice Burroughs populated the moon with monsters that came to conquer the earth, but he was not concerned as was Verne with probabilities, including even remote ones.

Our science fiction writers today know too much about the moon. But anyone with a romantic turn of mind need not abandon the hope that the moon, may yet surprise both the fantasizer and the scientist.

Returned nose cone splashes down in the Pacific after it's successful moon flight—from Jules Verne epic "From the Earth to the Moon" and "Round the Moon."

"It's
the last day
of
the old world"

—Arthur C. Clarke
British Writer



Blast Off,
Cape Kennedy, Fla.
July 16, 1969

Go, No Go:

Options that spell success

MAN'S first flight to the moon was not run on technological black magic. It ran instead on very precise planning, vast teams of people, who had to make up their minds more than seven years ago about what hardware to use and what maneuvers to make on a lunar landing mission.

The key principle was to allow the astronauts making the trip, and the ground controllers figuratively looking over their shoulders, plenty of opportunities to say: Thus far and no further.

NASA officials say they designed the moon flight to be as much like climbing a mountain as possible, with plenty of "plateaus" where people would have enough time to decide calmly what to do next: Go on, or come home?

Here is how their planning went:

THE first plateau is on the ground, at Kennedy Space Center on the sandy Atlantic shore of Florida, where the three stages of the Saturn V rocket are put together with their "brain," an instrument unit, and the three pieces of the actual Apollo moonship: the Command, Service and Lunar Modules.

If the pieces aren't ready—and there are millions of parts that could go wrong—the giant rocket does not take off. Or launching could be delayed by a pre-flight astronaut cold.

Once the launch occurs—and the Saturn V's have a record of being on time to the second—it takes less than 12 minutes for the third stage—bearing the Apollo moon-ship—to go into a parking orbit around the earth.

The second plateau comes one and a half orbits later, when the third stage is supposed to fire a second time to send the moon-ship on a course for the moon. If the third stage isn't ready on time, the astronauts would probably put in some extra time in practice flight around the earth.

IT IS said that about 90 percent of the planning effort in the U.S. space program concerns things that everyone wishes to goodness would never happen. And so far, few of the contingencies have ever come up.

At every plateau, there are alternate mission plans, and plans for what to do if something goes wrong at a particular time.

There are specific answers to the question: what do we do if the third stage cuts off early or late? And these plans are reflected in the wiring of the guidance computers on board the moon-craft.

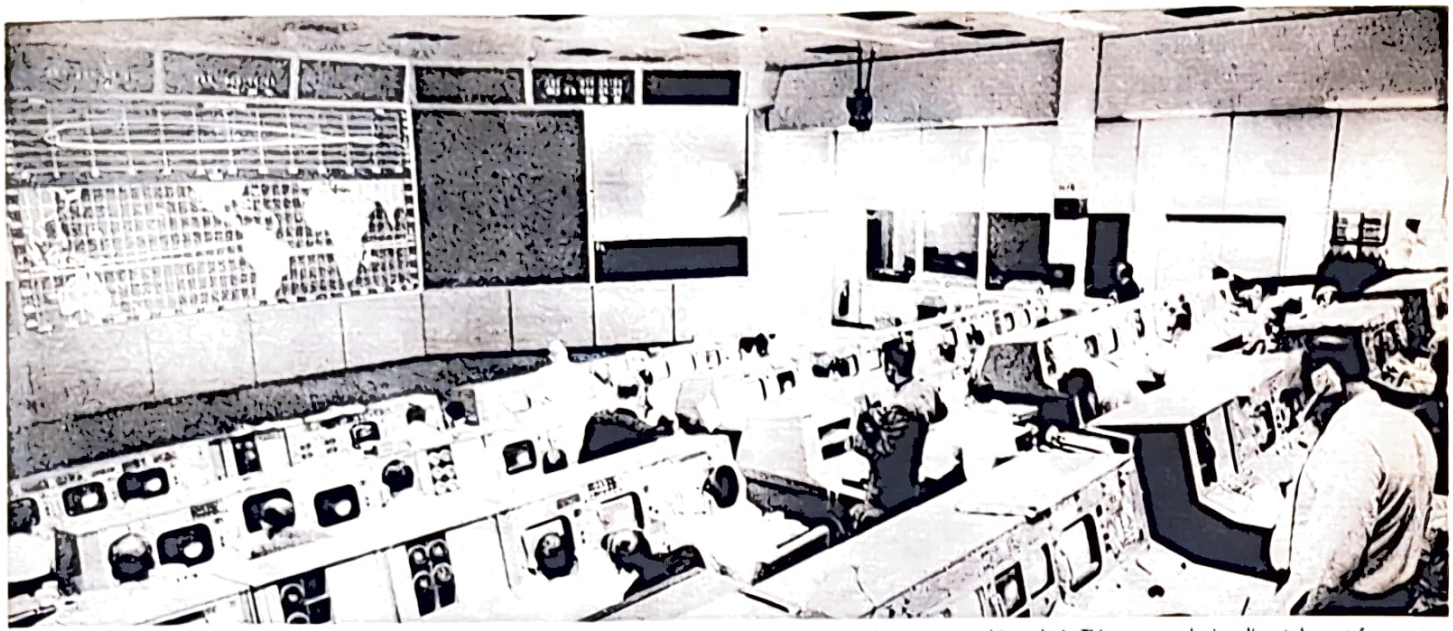
Once the Apollo ship is on its way to the moon, starting off with a speed of 24,300 miles an hour on a pathway slightly above the plane of the moon's orbit around the earth, trackers on the ground check out whether the pathway is good, and how much correction will be needed.

If all is well, the signal is given for the astronauts to pull a little away from the third stage, turn the nose of the Command Module around, and then dock with the spindly-looking Lunar Module, nesting on top of the rocket.

ONCE this is accomplished, the rocket and the moon-ship take up separate pathways in space and the astronauts begin three days of coasting toward the moon.

Again and again, they and their colleagues on the ground are presented with choices, whether or not to go into orbit around the moon, to take up a circular lunar orbit, to separate the Lunar Module for a descent to the surface, to insert the LM into a descent path down to 50,000 feet, to turn on the LM's braking rocket at 50,000 feet for the final approach to the desolate landing spot, and to land.

At each one of these points, it is possible to turn around.



Flight controllers in Mission Control center watching their TV screens during live telecast from space.

Mission Control

There's a "fourth astronaut" looking over their shoulders

At first glance, the windowless rooms near Houston, Texas, from which flights to the moon are controlled, seem small, almost cozy.

In these dark and quiet rooms, teams of engineers under the general direction of Christopher C. Kraft Jr., who together make up a kind of fourth Apollo astronaut, monitor every move of the most ambitious voyages so far made by man.

The engineers in Mission Control, building No. 30 of the Manned Spacecraft Center on a flat plain between Houston and Galveston, must know at every moment where the Apollo astronauts are and where they're going.

They must know more. The Apollo spacecraft which floats a quarter of a million miles to the moon, orbits it and detaches a lunar-landing taxi, is a miniature planet with water, oxygen, food, heat and electric power to keep three astronauts alive on an eight-day lunar mission. Mission Control must know the condition of all this equipment.

It also must make plans for emergencies, most of which never happen. For meeting real and potential hazards, they have the help of many engineers gathered in separate "support rooms," equipped like those in Mission Control with television display-tubes, flashing light indicators and one of the world's most powerful array of computers.

IF the "boys in the back room" can't come up with an answer, they can call on platoons of engineers from the dozens of major contractors involved in building the Apollo moonship, some of them on duty in a sort of bull-pen in a neighboring building and others on duty at the home office.

The duty engineers of the support rooms and Mission Control find themselves trying to figure out such problems as gas bubbles in a water bag or the reason for so-called "gyrations" during a maneuver close to the lunar surface, both of which happened during the Apollo 10 dress rehearsal for the lunar landing.

They distract themselves by trying to make ever-more-accurate calculations of Apollo's position in space, marveling at tracking so accurate that they can detect the effects of dumping waste water deep in space. The near-flawless performance of the Apollo equipment does not bore Mission Control.

The men who do this work are not stereotyped, briefcase-carrying experts, even though their language is occasionally ungrammatical and always choked with a space jargon full of such initials as: TLI (trans-lunar injection, or the blastoff from earth orbit to the moon), LOI (lunar orbit insertion), DOI (descent orbit insertion, the beginning of two astronauts' trip down to the lunar surface), and TEI (trans-earth injection, the start of the long voyage home).

FEW of the engineers of Mission Control hold advanced degrees, and one or two of them once were school dropouts reclaimed by the special demands of the Space Age. Some o. them fly planes. A lot have crewcuts. And one wears extremely loud vests – saving a wild, brocade number for the most important days of the flight.

The men of Mission Control are young. Those with the rank of flight director, immediately under Chris Kraft, are all in their 30's – Eugene F. Kranz (he of the vests), Gerald D. Griffin, M.P. (Pete) Frank, Glynn S. Lunney, Milton L. Windler, Clifford E. Charlesworth.

Even younger are such specialists as the Electrical, Environmental and Communications systems engineers (called EECOMs), the Flight Dynamics Officers, the Guidance Officers and the Retrofire Officers called FIDO, GUIDO and RETRO.

THE radio communications for project Apollo are powerful enough to make it seem that the astronauts are just across the hall even though they can be a quarter of a million miles away in orbit around the earth's natural satellite.

Flight Director Christopher C. Kraft puffs a cigar in Mission Control, Houston.

With the aid of multiple channels of communications and batteries of computers and television display tubes, the engineers of Mission Control are always at the elbow of the astronaut-explorers. They consult, advise, warn, and give information that the astronauts would need for coming home even if the communications blacked out.

Thus, with the help of mission Control and their own equipment on board, Apollo astronauts can navigate to the moon – and so trust the accuracy of their navigation that they can make their close approach and go into orbit around the moon without being able to see it below them.

They take their location on faith – faith in their on-board equipment and in the fourth astronaut: Mission Control.

Just ahead

Moon base, then space stations

APOLLO 11 is only the first of a planned series of 9 moon landings which will systematically explore the lunar surface.

According to Dr. Thomas O. Paine, administrator of the National Aeronautics and Space Administration, (NASA) the next three Apollo missions will be similar to the first but will carry increasingly heavier loads of scientific equipment.

The first four landings will leave equipment to measure lunar disturbances and reflect laser beams back to earth but the final five will be on different parts of the moon and may include overland exploration, Paine said.

"We're talking here really about man's conquest of the seventh continent," he said, noting that the moon is about as large as the Earth's land area.

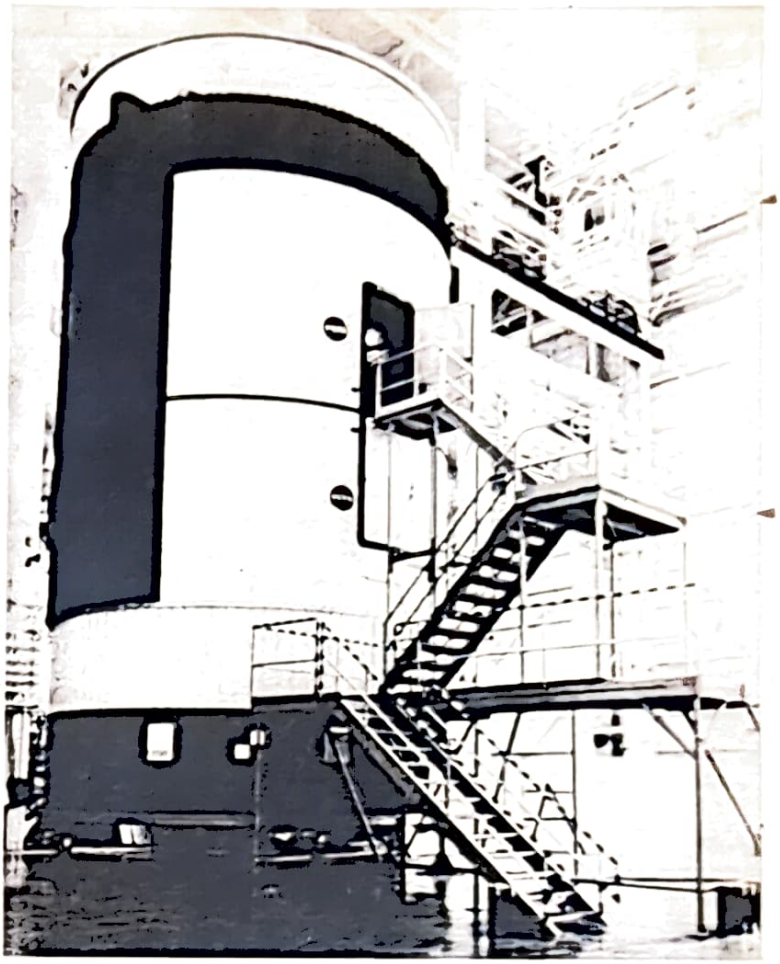
Paine predicted that the U.S. will have a small manned base on the moon by the end of the 1970s.

The next eight moon flights will be made with Saturn rockets now in production but a "near earth" exploration program is planned with the smaller Saturn IB rockets left over from Apollo earth orbital missions.

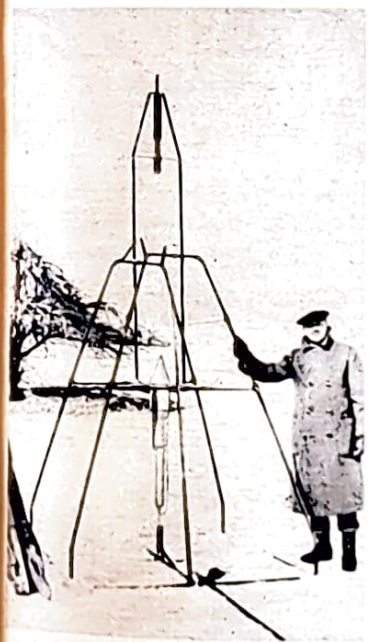
"These are rockets which weren't used up in preliminary Apollo flights because we made substantially more progress than our rather conservative early estimates had led us to believe we would," Paine said.

The NASA chief said the Apollo applications program will put men into space first for 28 days and then for 56 days at a time with advanced astronomical equipment to study the sun and demonstrate how long men can work effectively in a weightless atmosphere – a necessary prelude to a voyage to Mars.

WITH the engineering data acquired in these long orbital flights, a large space station will be designed using the upper stage of a Saturn V rocket. The so-called S-IV-B second stage is about 21 feet in diameter and about 58 feet long, more than big enough for men to live and work. The space station would be in effect an artificial "moon" from which scientists could observe terrestial phenomena such as tornadoes and help unlock the secrets of weather.



The Saturn IB second stage will serve as an orbiting space laboratory. In this mock-up are crew quarters and laboratory areas.



World's first successful test of a liquid-fueled rocket came on March 16, 1926 in Auburn, Mass. A few minutes after this photo was taken, the rocket shot several hundred feet into the air. Dr. Robert H. Goddard of Worcester (above) had patented a multi-stage rocket as early as 1914. Rocketry of the gunpowder variety had been known much earlier. First recorded use of rockets was at the seige of Kaifeng, China, in the year 1232.

U.S. vs. Russia:

A race where both contestants are winners

APOLLO 11's triumphal flight has given the U.S. a solid lead in the space race but no one is ruling out a Soviet comeback.

"The United States has the capability to operate in space and to carry out almost any operation which the Soviets can carry out today, except that we still haven't soft-landed packages of instruments on the planets," according to Dr. Thomas O. Paine, chief of NASA.

The space race has been an "up and down" affair, with the Russians stealing a march by launching Sputnik I on Oct. 4, 1957, and again on April 12, 1961, when Cosmonaut Yuri Gagarin became the first man to orbit the earth.

"From the standpoint of 'first', of course, the Soviet Union had a long string of them, most of which go back to the early 1960's," Paine said.

The civilian space agency chief notes that on two separate occasions the Soviets have placed instruments within the atmosphere of Venus – almost to the surface of the planet.

On the other hand, U.S. planetary "fly-bys" using sophisticated eletronic equipment have acquired a great deal of information and transmitted it back to earth.

"So, I think that in the electro-sensing end we have a slight lead; in the ability to soft-land perhaps they do," Paine said.

(The Russian Luna 15, which orbited the moon during the Apollo 11 flight, was rumored to be attempting a soft landing, collection of material from the lunar surface, followed by a return to the Soviet Union. Its radio signals terminated suddenly when it appeared to be attempting the landing.)

The U.S. appears to be well ahead of the Soviets in manned flight but the Russians have similar capabilities when it comes to putting a large payload into orbit – although we seem to lead in space applications such as communications, navigation, and geodetic satellites.

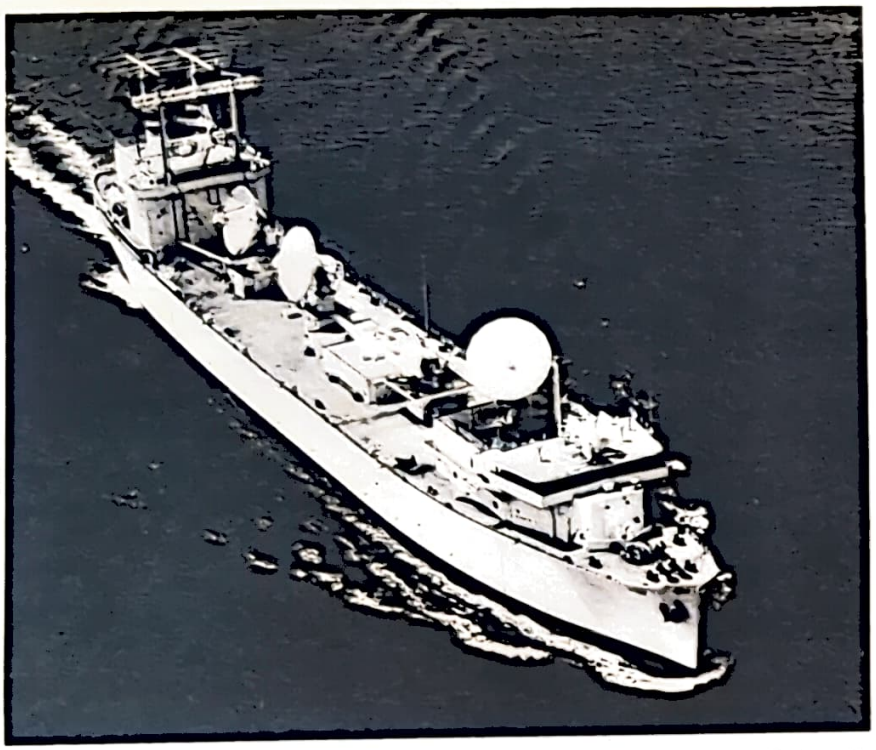
What each of the two super powers does in space in the future will be a matter of "national wills," Paine thinks.

"A lot depends on the national wills. Both of us have the technology and resources to make rapid progress in space. We've both put together the teams and we have the equipment; we have the institutions and facilities that will allow us, if we choose, to make substantial progress in the 1970's and 1980's. The questions is one of national imagination, national daring, national will."

Paine said the Russians can be expected to continue to put great stress on space and to make steady progress while there is a danger that having attained the moon the U.S. will "slack off."

"If that were the case and we were not to start new programs now," Paine said, "I think the situation might well reverse and the Soviets might once again develop superior technological capabilities in space."

New England:



USNS Redstone, one of three Apollo Instrumentation ships built by General Dynamics at Quincy, Mass. She and sister ships Vanguard and Mercury are highly sophisticated electronic tracking ships

As the astronauts hurtled through space, the success or failure of their mission was governed greatly by the work of New England scientists, engineers and industrial concerns.

New England was involved from the time President Kennedy announced the moon landing as a national goal in 1961.

Some of the contributions:

– The black box wizardry that guided the astronauts across the void of space and back was conceived in a brain tank known as the M.I.T. Instrumentation Laboratory.

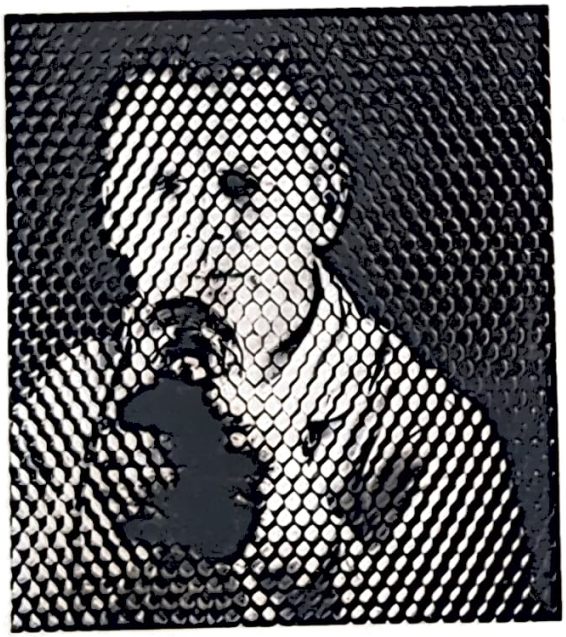
– The critical maneuvers of the command and lunar modules were controlled by miniature digital computers produced at the Raytheon Co. plant in Waltham.

– As the astronauts returned from their historic venture, an inches-thin heat shield, made of a plastic-type material developed by the Avco Applied Technology Division in Lowell, protected them and their spacecraft from being burned to a cinder.

– The landing radar and rendezvous radar-transponder systems, so critical for the touchdown of the lunar module and its later return to its mother craft, were built by RCA in Burlington.

– General Dynamics in Quincy converted three World War II tankers into sophisticated sea-going instrumentation stations to serve as vital links in tracking the spacecraft and communicating with

Gep Chen, an RCA Aerospace Systems Division engineer in Burlington, Mass., tests rendezvous radar for lunar module.



Camera's eye view of a section of fiberglass honeycomb, which when injected with ablative material and baked, becomes the heat shield for Apollo reentry into earth's atmosphere. Avco Applied Technology Division in Lowell developed and manufactures the thermal protection system.

Apollo DSKY (display and keyboard), is manufactured by Raytheon Company's Equipment Division. It is the visual and electronics link between astronauts and the guidance computer.

Its top role in Apollo success

the astronauts as well as monitoring the performance of both men and machine.

SCIENTISTS and engineers at the M.I.T. Instrumentation laboratory had several roles in the Apollo mission, but perhaps the most amazing was development of a system that has been described as astronomy in a closet.

The system consists of three major elements: inertial measurement, computer and optical units.

This guidance and navigation package is mounted inside the spacecraft on the wall of the lower equipment bay at the foot of the astronaut occupying the middle couch.

It takes up only four-by-three feet of wall space, but uses all known methods obtaining information for guidance and navigation, i.e., inertial, celestial, on-board radar and ground tracking, hence the description as astronomy in a closet.

Besides the conception, design and development of the guidance, navigation and control systems for the Command and Lunar modules, the Instrumentation Laboratory had several other roles in the Apollo program, including:

—Development of the program for the guidance and navigation system computer for each Apollo mission.

—Support for mission controllers at Cape Kennedy and at Houston during each mission.

—Training of Apollo crews in the general principles of space guidance and navigation and the use of the spacecraft's systems.

The Laboratory's contribution to Apollo was primarily conceptual, intellectual and educational. All production was carried out by private industry working under contract for NASA.

RAYTHEON, for instance, had a wide range of involvement in the Apollo program. Besides the miniature digital computers, the company also worked on:

—Development and production of the powerful amplifier that boosted communications signals from the lunar module.

—The program of selecting the landing site for the historic touchdown.

—Production of the display keyboards (DSKY's, pronounced diskies) used by the astronauts as the control centers for guiding the two spacecraft.

—Development and production of a display system for checking out the first stage of the Saturn V rocket which powers the lift-off from earth.

—Development of a unique testing method to insure extra-high reliability of the critical components of the spacecraft.

In addition, Raytheon developed and installed a large computing system at Houston and also a special radar tracking system at Wallop's Island, Va.

Avco devoted three years of research to develop the heat shield which kept the astronauts comfortable at about 70 degrees inside the command module during reentry, despite temperatures of 5000 degrees as they scorched through the atmosphere.

KNOWN as an ablative shield, it controls the rate of heat absorption by the space vehicle's metal structure through a combination of vaporizing and charring or ablating.

This allows the heat reaction to consume the ablative material (about 300 pounds in a 15-minute period) rather than the vehicle itself.

RCA in Burlington built the landing radar and rendezvous radar transponder systems so essential to the touchy landing and all important lift-off from the moon.

The landing radar provided continuous measurements of the craft's altitude and velocity relative to the moon's surface during the final phases of descent and landing.

The radar mounted on the lunar landing craft sent a continuous wave signal back to a transponder aboard the mother craft.

THE transponder re-transmitted the signal back to the radar. By measuring characteristics of the returned signal, the radar determined range, direction and velocity of the landing craft relative to the command module.

The three ships converted by General Dynamics in Quincy, the Vanguard, Mercury and Redstone were greatly enlarged, or "jumbolized," providing space for the sophiscated tracking instrumentation and living quarters for a crew of 85 and for 108 technicians.

Lunar module (Snoopy) nears Apollo 10 command capsule from its journey close to the moon. Rendezvous radar made by RCA in Burlington, Mass., makes this maneuver possible. Red-blue line is window frame of command capsule.

Mars surface 2000 miles below Mariner VI — Man's closest view to date.

Mars (at left) seen from 573,000 miles, with its South polar cap at bottom. The cap shows irregular edges scientists think may be Martian mountains. The minimum-distance fly-by photograph (above) shows moon-like craters never before seen by man. The 1969 Mariner views are not expected to show evidence of life but merely to indicate likely spots to check on Mars orbiter flights planned for 1971 and 1973.

Mars: the next great leap into space

THE exploration of Mars by Mariners VI and VII, which are only the second and third operating spacecraft to approach the Red Planet, merely opens the door to more detailed studies later.

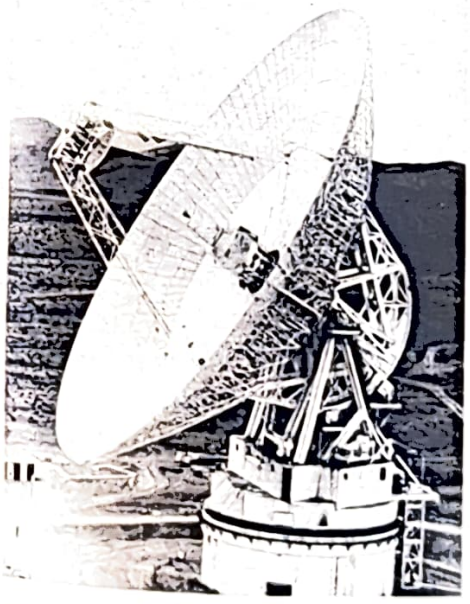
The close examination of the planet by television cameras and infrared and ultraviolet instruments for measuring surface temperature and the composition of the atmosphere, occurring as it does immediately after a manned lunar landing, may well strengthen the vision of an eventual landing on Mars.

Such a landing cannot occur, however, before man learns a great deal more about the only planet whose surface can be studied by optical telescopes located on the surface of the Earth, (the planet closest to Earth, Venus, is masked by thick clouds, as is Jupiter).

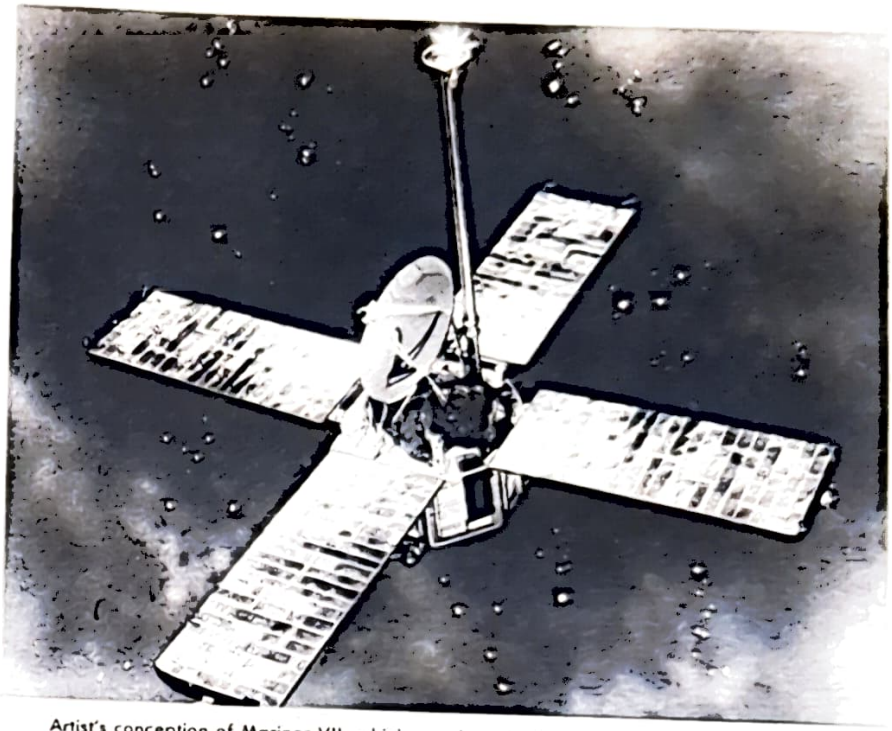
Some of the necessary knowledge will have to be acquired indirectly. Astronauts who visit many different places on the surface of the moon, gradually staying longer, moving farther from their landing craft, using tractors and rocket belts and perhaps setting up a small permanent base, may well be getting the essential practice for, say, a 40-day stay on Mars in 1986-88.

PRESUMABLY, astronaut visits on the moon will be restricted to a few weeks for many years to come. Where they will put in their longest residences away from Earth will be in space stations orbiting near enough to Earth to permit a swift return in case of trouble.

In such space stations, men will learn the physiological and psychological lessons they will need to undertake a voyage to Mars.



Capable of tracking spacecraft as far as 200 million miles into space, this 210-foot diameter tracking and communications antenna is located near Goldstone, Calif., in the Mojave desert. It received the Mars fly-by photographs taken by Mariners VI and VII.



Artist's conception of Mariner VII, which was launched towards Mars on March 27, 1969

But the most important knowledge of Mars will have to be gathered near it or on it by unmanned spacecraft, the most sophisticated descendants of this Summer's Mariner VI and Mariner VII.

Spacecraft for missions to Mars in 1971 and 1973 are already being built. In 1971, two Mariners are to be placed in orbit around Mars, with the aim of getting data for several months.

In 1973, two much larger crafts, called Vikings, are to be placed into orbit, one around the Martian equator and the other over the poles.

THESE two Vikings will carry small landing craft, which will be detached from the orbiters and sent down to areas on the surface which previous surveys have shown to be interesting, that is, showing signs of volcanic activity or perhaps even of moisture or greenery.

Most scientists do not expect Mars to be a very hospitable environment for life, although they don't rule out the possibility that life may have existed there previously.

The atmosphere of Mars is only about one hundredth as thick as our own, according to measurements taken by the first operating spacecraft to view Mars close up, the American Mariner IV in 1965. The atmosphere appears to be largely composed of carbon dioxide.

In such a thin atmosphere, any water on the surface vaporizes quickly and so the idea of water-filled canals or seas on Mars does not ring true to scientists, although lines looking like canals have been seen.

A MEASUREMENT of the amount of water in Mars' atmosphere taken last March indicate that there is only one cubic mile's worth on the whole planet, and much of that may be tied up as a thin layer of frost in the polar icecaps (unless these are made of frozen carbon dioxide). The earth's endowment of surface water is about 300 million cubic miles.

In the dry, thin atmosphere of Mars, temperatures may vary as much as 200 degrees fahrenheit between high noon (when it might reach 70 degrees at noon in Summer at the surface) and the darkness before the dawn (which comes, as on Earth, every 24 hours).

It may be also that the air is warm right at the surface but below zero only a short distance above. An astronaut standing on the surface might well have a temperature of 70 degrees under his feet and 10 degrees below zero at his helmet.

Such variations would cause trouble for anything living.

BUT there is another problem. The thinness of the atmosphere opens up the surface of Mars to heavy bombardment of deadly radiation from space. And furthermore, Mars lacks a magnetic field around it, which provides the earth with an important additional shield against radiation.

Mars, like the moon, is very likely to be a fascinating place to visit but unappetizing for long residence. Its main usefulness for the inhabitants of the earth is likely to be lessons about how to live in better harmony with nature at home.

Minimum planetary distances

Earth to Moon . . . 221,463 miles
Earth to Mars . . . 34,600,000 miles

"We're proud to be back . . . proud of what we accomplished"—Michael Collins sums up feeling of all three astronauts as they land safely in Pacific Ocean. Lt. Clancy Hatleberg closes hatch door as spacemen sprawl in liferaft, awaiting helicopter taxi to deck of carrier Hornet. Men wore isolation garments to avoid possible contamination of earth.

Return to Earth,
July 24, 1969
12:50 P.M.